Title of article: Advanced Microgravity Acceleration Measurement Systems (AMAMS)

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Web addresses: http://microgravity.grc.nasa.gov/

Glenn contacts: Ronald J. Sicker, NASA GRC (216) 433-6498, Ronald.Sicker@grc.nasa.gov and
Thomas J. Kacpura, Zin Technologies (216) 433-0420, Thomas.Kacpura@grc.nasa.gov

Author(s): Ronald J. Sicker, Thomas J. Kacpura

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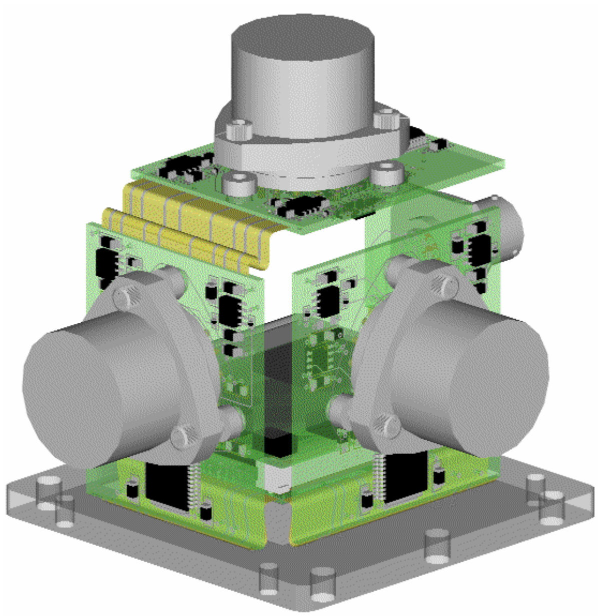
Introduction:

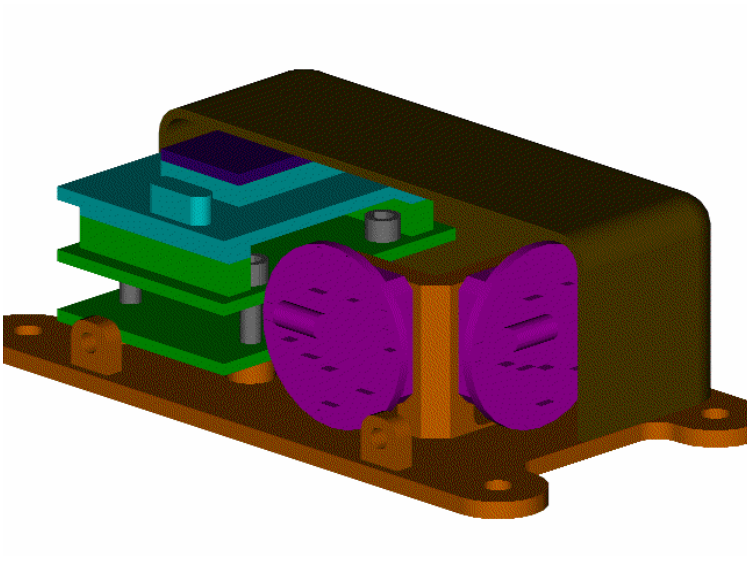
The Advanced Microgravity Acceleration Measurement Systems (AMAMS) project is part of the Instrument Technology Development (ITD) program to develop advanced sensor systems. The primary focus of the AMAMS project is to develop Micro-Electronic-Mechanical (MEMS) acceleration sensor systems to replace existing electro-mechanical sensor based systems presently used to assess relative gravity levels aboard spacecraft. These systems are used in the characterization of both vehicle and payload responses to low gravity vibro-acoustic environments. The collection of microgravity acceleration data has cross-disciplinary utility to microgravity life and physical sciences, and structural dynamics communities. The inherent advantages of semiconductor-based systems are reduced size, mass and power consumption, while providing enhanced long term calibration stability.

The AMAMS represents the fifth generation of triaxial sensor heads developed at GRC for the collection of microgravity acceleration data. Since 1991 the Space Acceleration Measurement System (SAMS) program has supported over 25 shuttle missions, the Space Station Mir and has on-going operations on the ISS. The first four generations; (original) SAMS 1991- 1998, SAMS-FF 1999-2003, SAMS-II (for ISS) 2001-present and SAMS

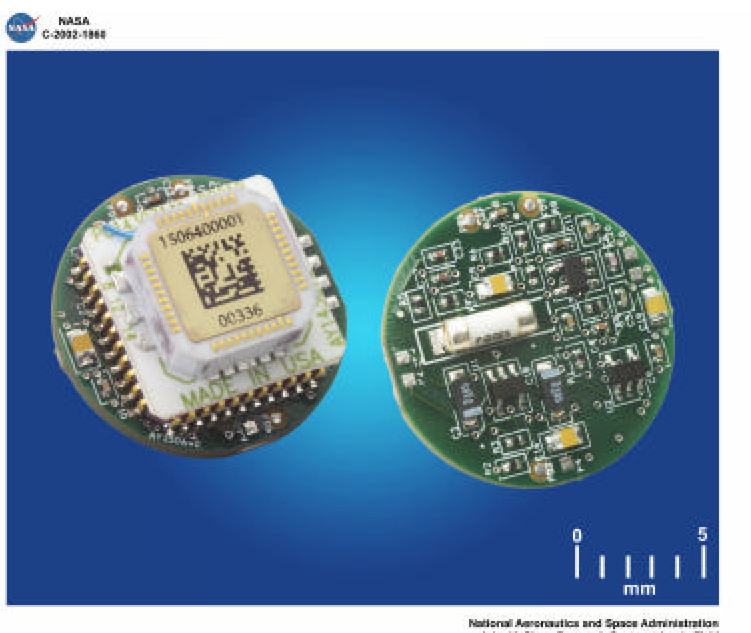
TSH-ES (Ethernet) 2002-present, share a common design approach of using the Allied Signal Q-flex accelerometers (pictured below). AMAMS represents a new design approach using MEMS accelerometers (pictured below) and state of the art analog to digital converters. In addition to the significant savings in on-orbit resources it is theorized that AMAMS would be more accurate for long duration (longer then 2 years) interplanetary missions since they do not use magnetics in the sensor. The long term accuracy and stability will be demonstrated with ground testing and operational experience.



SAMS TSH-ES Showing mounting of Allied Signal QA-3000 and electronic interface card.



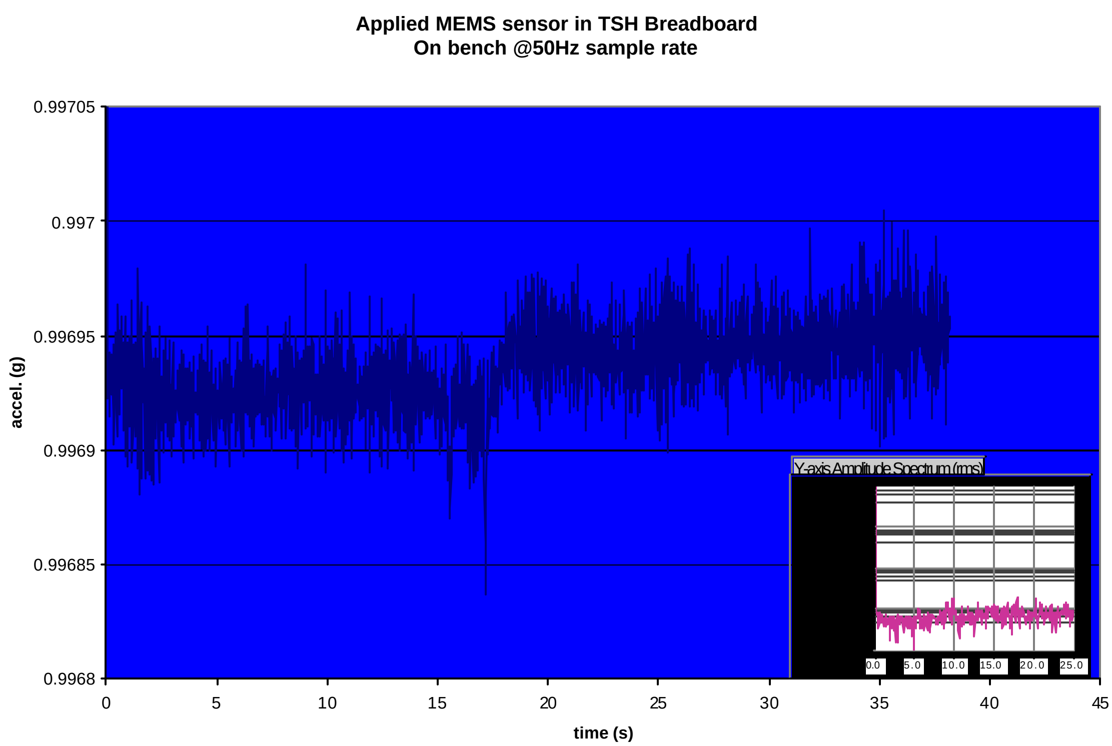
AMAMS design using Applied MEMS accelerometer and electronic interface card. Note the small size allows the accelerometers to face inwards.



MEMS accelerometers.

Progress to date:

A market survey assessed three different MEMS accelerometers from Honeywell, Allied Signal and Applied MEMS that could produce microgravity (1x10-6g or 1 micro-g) resolution. A test program was conducted, and it was determined that the Applied MEMS sensor possessed the best combination of characteristic for a microgravity triaxial sensor head. These MEMS sensors were developed for the seismic and geological exploration communities, where the reduced size and weight offer inherent advantages over conventional mechanical devices. Testing was conducted with the Applied MEMS at the Space Power Facility (SPF) at the Plum Brook Facility to determine the noise floor. The results (see below) were very encouraging yielding data that demonstrated that the Applied MEMS accelerometer combined with the prototype electronics has the performance to produce microgravity resolution in the general purpose 0.1 to 25 Hz range. The testing also verified the available 1500 Hz bandwidth of the Applied MEMS sensor.



A design has been completed for the prototype triaxial sensor head that met the goals of the ITD proposal. High resolution 24 bit delta sigma analog-to-digital conversion circuitry is employed to utilize the large dynamic range of the accelerometers. This sensor head design is controlled with a commercial processor board, and has a RS-422 serial interface for external control and data storage. The resulting sensor head meets the goals of sensitivity less than 1 micro-g, with a resulting packaging size of under 8 cubic inches; weight under 0.25 pounds, power consumption less than 1 Watt, with a component cost of under $2500. This represents a 33% reduction in volume, an 87% reduction in cost, and 50% reduction in power consumption from previous designs. The prototype of this sensor is scheduled for completion in January 2003, and integrated testing is scheduled with the completed package.

In addition, a design study was conducted to investigate further miniaturization of the sensor package. This would be accomplished through development of a custom hybrid package or application specific integrated circuit (ASIC) for the signal conditioning and processor electronics circuitry. Several different designs were developed for progressively reducing the size as more sophisticated packaging techniques were employed. It is feasible to develop a triaxial sensor package that would be less than five cubic inches, and utilize an Ethernet interface so that it could be implemented to the ISS Ethernet local area network. The smaller size requires less volume and allows the sensors to be located closer to the measurement location.

This work is part of a multiyear (2001 – 2003) effort funded by the NASA Office of Biological and Physical Research, based on a competitive proposal co-authored by Thomas J. Kacpura and Ronald J. Sicker. The work will be performed primarily at Zin Technologies with NASA management oversight.